

arrangement of the user interface system **100** suitable to providing tactile guidance and/or detecting user input may be used.

[0024] The sheet **111** of the preferred embodiment functions to define a surface **115** on one side and at least partially defines a plurality of cavities **125** on an opposite side. The sheet **111** preferably includes a layer **110** that defines the surface **115** and a substrate **120** that supports the layer **110** and at least partially defines the plurality of cavities **125**. The sheet **111** is preferably similar to the sheet and layer taught in U.S. application Ser. No. 12/319,334, but may alternatively be any suitable device that a sheet **111** that defines a surface **115** on one side and at least partially defines a plurality of cavities **125** on an opposite side.

[0025] As shown in FIGS. **3a**, **3b** and **3c**, the cavities **125** of the preferred embodiment each function to hold a fluid and to have at least two volumetric settings: a retracted volume setting (shown in FIG. **3a**) and an expanded volume setting (shown in FIG. **3b**). When in the expanded volume setting, the user may inwardly deform the particular region **113** to provide a user input (shown in FIG. **3c**). The fluid is preferably a liquid (such as water, glycerin, or ethylene glycol), but may alternatively be a gas (such as air, nitrogen, or argon) or any other substance (such as a gel or aerogel) that expands the cavity **125** and deforms the surface **115**. In the expanded volume setting, the cavity **125** expands above the plane of the surface **115**, thereby deforming a particular region of the surface **115**. The deformation of the particular region **113** functions to provide tactile guidance and/or tactile feedback on the surface **115** for the user. The deformation of the particular region **113** also preferably functions to inform the user of the type of input the deformation represents. For example, the deformation of the particular region **113** may be of a shape that indicates the type of input that the deformation represents. Alternatively, the sheet **111** may include tactile instructions, for example, a pattern of beads or substantially small protrusions that may be felt by the user on the particular region **113** that indicate the type of input the deformation represents. The tactile instructions on the particular region **113** may alternatively be any other type of feature that is able to be felt tactilely by the user.

[0026] As shown in FIGS. **4-5**, the plurality of cavities **125** and the displacement device **130** are preferably coupled to the fluid network **200**, which functions to allow fluid to communicate through the user interface system **100** to expand and retract the plurality of cavities **125**. The fluid network **200** preferably includes a channel **138** that preferably couples each of the plurality of cavities **125**, either directly or indirectly (shown in FIG. **6**), to the displacement device **130**. The channel **138** may be composed of a plurality of segments (or “branches”) that couple to each of the plurality of cavities **125** and the displacement device **130**. The fluid network **200** may also include a reservoir **132** that functions to contain a volume of the fluid.

[0027] Each of the plurality of cavities **125** preferably function substantially similarly and are expanded and retracted by fluid displaced by the displacement device **130**. In some variations, the plurality of cavities **125** may be substantially similar to each other. In other variations, the plurality of cavities **125** may have differences in overall geometry, volume, expansion properties, and/or retraction properties. The plurality of cavities **125** preferably provide the user interface system **100** with the ability to adapt to a variety of user

interface scenarios, for example, to user interface scenarios that require more than one possible input (e.g. “Yes” or “No”).

[0028] As shown in FIGS. **4a** and **4b**, the displacement device **130** of the preferred embodiment functions to expand the cavity **125**, subsequently deforming the particular region **113** of the surface **115**. The displacement device **130** preferably functions to both expand and retract the cavity **125**. In other words, the displacement device **130** functions to increase the volume of fluid within the cavity **125** and decrease the volume of fluid (or “drain” fluid) in the cavity **125**. The user interface system **100** may, however, use another device or method to decrease the volume of fluid. The displacement device **130** may be one of several variations. In a first variation, as shown in FIG. **5a**, the displacement device **130** includes a linear actuator that displaces fluid in between the displacement device **130** and a cavity **125**. In a second variation, as shown in FIG. **5b**, the displacement device **130** includes a heating element (for example, a resistive heater composed of a material such as TaN or Nichrome) that functions to expand the volume of fluid contained within a cavity **125**. In a third variation, as shown in FIG. **5c**, the displacement device **130** includes a micro-pump **134** (for example, pump #MDP2205 from ThinXXs Microtechnology AG of Zweibrücken, Germany or pump #mp5 from Bartels Mikro-technik GmbH of Dortmund, Germany) that pumps fluid from a reservoir **132** to a cavity **125**. The micro-pump **134** preferably pumps fluid between the cavity **125** and the reservoir **132**. In a variation of the fluid where the fluid is ambient air, the pump **134** may function to pump air from the surrounding environment into the cavity **125**. The third variation may alternatively include two micro-pumps **134**, a first to pump fluid into the cavity **125** from the reservoir **132** and a second to pump fluid from the cavity **125** into the reservoir **132**. However, any other suitable type of displacement device **130** may be used.

[0029] Although the cause of the deformation of a particular region **113** of the surface **115** has been described as a modification of the volume of the fluid in the cavity **125**, it is possible to describe the cause of the deformation as an increase in the pressure below the surface **115** relative to the pressure above the surface **115**. When used with a mobile phone device, an increase of approximately 0.1-10.0 psi between the pressure below the sheet **110** relative to the pressure above the sheet **110**, is preferably enough to deform a particular region **113** of the surface **115**. When used with this or other applications, however, the modification of the pressure may be increased (or possibly decreased) by any suitable amount. For example, when the user interface system **100** is used in environments with different ambient pressures such as in an airplane where ambient pressure is lower than that closer to sea level, the displacement device **130** may be adjusted to provide less of a pressure change to achieve the same level of expansion of the cavity **125**. Additionally, each of the plurality of cavities **125** may expand with a different pressure change; for example, a first cavity **125a** may expand with a change of 0.1 psi while a second cavity **125b** may expand with a change of 0.5 psi.

[0030] As mentioned above, the user interface system **100** preferably includes a plurality of cavities **125**. The displacement device **130** preferably expands the plurality of cavities **125** in one of four preferred embodiments. In a first preferred embodiment, as shown in FIGS. **6-7**, the displacement device **130** preferably expands a first cavity **125a** and a second cavity